CIRCULAR KNITTING MACHINE, PARTICULARLY FOR PRODUCING ITEMS OF CLOTHING WITH THREE-DIMENSIONAL SHAPES

Technical Field

The present invention relates to a circular knitting machine, particularly for producing items of clothing with three-dimensional shapes.

Background Art

Circular knitting machines with a diameter substantially comprised between 7 and 24 inches are known. In recent years, these machines have become widespread as a consequence of the increasing demand for items of clothing, such as for example jerseys, light jerseys, bodysuits, briefs, bras or the like, provided without lateral seams, and as a consequence of the possibility to provide directly on these machines finishing work, such as for example borders, shoulder straps or others, without having to resort to subsequent operations.

In the production of certain items of clothing, such as for example bodysuits and bras, it must be possible to provide three-dimensional shapes aimed at improving the fit and aesthetics of the item of clothing. This requirement is currently met by means of solutions that generally consist in varying the tightness of the knitting and/or in making a set of needles knit for a preset number of courses of knitting while the other needles remain unused, optionally using particularly elastic yarns. However, these refinements do no fully meet the requirements, since a variation in the tightness of the knitting causes a variation in the degree of sheerness of the item of clothing, whereas making a set of needles knit while the other needles are inactive entails trimming the yarn knitted by the needles that are then excluded from knitting, with negative effects on the fit of the item of clothing.

Disclosure of the Invention

The aim of the present invention is to solve the problems described

above by providing a circular knitting machine that allows to obtain items of clothing with three-dimensional shapes without necessarily resorting to a variation in the tightness of the knitting and without forming portions of courses of knitting with final trimming of the yarns used to produce said course portions.

Within this aim, an object of the invention is to provide a machine that allows to produce reinforcement gussets and shapes at preset regions of the article to be produced according to a preset knitting program.

Another object of the invention is to provide a circular machine that is also capable of performing intarsia knitting, i.e., designs with colored patterns without floated yarns on the reverse side of the knitting.

Another object of the invention is to provide a machine that is extremely versatile and can perform a wide range of types of knitting.

This aim and these and other objects that will become better apparent hereinafter are achieved by a circular knitting machine, comprising a footing that supports a needle cylinder that can rotate about its own axis, which is orientated substantially vertically, said needle cylinder having a diameter that is substantially comprised between 7 and 24 inches, multiple axial slots being formed on the outer lateral surface of the needle cylinder, each slot accommodating a needle, means for actuating the needles being provided which interact with said needles during the rotation of the needle cylinder about its own axis for the actuation of the needles along the corresponding axial slot of the needle cylinder so that the needles form knitting with at least one yarn dispensed to the needles at at least one drop or feed of the machine, characterized in that said needle cylinder can be rotationally actuated about its own axis in both directions of rotation and in that said needle actuation means are suitable to allow the needles to form knitting in both directions of rotation of the needle cylinder about its own axis at at least one drop or feed of the machine.

Brief description of the drawings

Further characteristics and advantages of the invention will become better apparent from the description of a preferred but not exclusive embodiment of the machine according to the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a schematic flat projection view of a portion of the cam box of the machine according to the invention, in a first operating condition;

Figure 2 is a schematic flat projection view of a portion of the cam box of the machine according to the invention in a second operating condition;

Figure 3 is a schematic flat projection view of a portion of the cam box of the machine according to the invention in a third operating condition;

Figure 4 is a schematic flat projection view of a portion of the cam box of the machine according to the invention in a fourth operating condition;

Figure 5 is a schematic axial sectional view of the needle cylinder of the machine according to the invention, with a sub-needle in the inactive position;

Figure 6 is a schematic axial sectional view of the needle cylinder of the machine according to the invention, illustrating the transition of the sub-needle from the inactive position to the active position;

Figure 7 is a schematic axial sectional view of the needle cylinder of the machine according to the invention, with the sub-needle in the active position;

Figure 8 is a schematic axial sectional view of the needle cylinder of the machine according to the invention, with the sub-needle in the active position, during the lifting of the overlying needle.

Ways to carrying out the Invention

With reference to the figures, the circular knitting machine according to the invention, generally designated by the reference numeral 1 and shown only schematically and partially, comprises, like known types of machine, a

footing, not shown for the sake of simplicity, which supports a needle cylinder 2, which can rotate with respect to the footing about its own axis 2a, which is orientated substantially vertically. The needle cylinder 2 has a diameter that is substantially comprised between 7 and 24 inches, and multiple axial slots 3 are formed on its outer lateral surface; each slot accommodates a needle 4.

The machine comprises means for actuating the needles 4, which are described in greater detail hereinafter and interact with the needles 4 during the rotation of the needle cylinder 2 about its own axis 2a in order to actuate the needles 4 along the corresponding axial slot 3 so that the needles 4 form knitting with at least one yarn, which is dispensed to the needles 4 at at least one feed or drop 5, which is arranged laterally to the axis 2a and at which appropriately provided yarn fingers 6 are positioned.

According to the invention, the needle cylinder 2 can be actuated so as to rotate about its own axis 2a in both directions of rotation, and the means for actuating the needles 4 are suitable to allow the needles 4 to form knitting in both directions of rotation of the needle cylinder 2 about its own axis 2a at at least one drop 5.

Depending on the knitting requirements, the needle cylinder 2 can be actuated with a continuous motion in one direction of rotation or in the opposite direction or with an alternating (or oscillating) motion about its own axis 2a.

For the actuation of the needle cylinder 2 with a rotary motion about its own axis 2a, it is possible to use an electric motor of a known type, which allows to reverse the rotation of its output shaft, or said reversal of the rotary motion can be achieved by means of a transmission that is interposed between the motor and the needle cylinder 2.

The needle cylinder 2 can have, in a per se known manner, means for controlling its angular position around the axis 2a, for example devices such as encoders or the like, so as to allow to control the position of the various

needles 4 around the axis 2a during the rotation of the cylinder 2.

The machine is preferably provided with a control and actuation element of the programmable electronic type, which supervises the operation of the various elements of the machine so that it can perform knitting according to preset programs.

Preferably, the machine according to the invention has four drops or feeds 5, which are angularly mutually spaced around the axis 2a of the needle cylinder 2.

Preferably, the means for actuating the needles 4 are provided so as to allow the needles 4 to form knitting in both directions of rotation of the needle cylinder 2 about its own axis 2a at all the drops 5.

Figures 1 to 4, described in detail hereinafter, are flat projection views of a portion of the cam box of the machine. The illustrated portion refers to the portion that relates to a little more than one drop 5, and preferably this configuration of the cams is repeated as regards the other drops of the machine.

The means for actuating the needles 4 comprise, for each needle 4, a sub-needle 7, which is arranged below the corresponding needle 4 in the same axial slot 3 of the needle cylinder 2. The sub-needle 7 is connected bilaterally, in its motion along the corresponding axial slot 3, i.e., parallel to the axis 2a of the needle cylinder 2, to the overlying needle 4, and has, along its longitudinal extension, a heel 7a, which is orientated radially with respect to the needle cylinder 2. The bilateral connection between the needle 4 and the sub-needle 7 is achieved by means of a particular geometric coupling between the upper end of the sub-needle 7 and the lower end of the needle 4. This coupling, in addition to providing said bilateral connection, allows the sub-needle 7 to oscillate on a radial plane of the needle cylinder 2 in order to pass from an active position, in which it is extracted radially with its heel 7a from the corresponding axial slot 3 of the needle cylinder 2, to an inactive position, in which it is embedded with its heel 7a in the

corresponding axial slot 3.

Sub-needle actuation cams, generally designated by the reference numeral 8, face and lie around the outer lateral surface of the needle cylinder 2, at a level that corresponds to the level of the heels 7a of the sub-needles 7, are rigidly coupled to the footing of the machine as regards rotary motion about the axis 2a, and define paths that are engaged by the heels 7a of the sub-needles 7 when they are in the active position and vice versa are not engaged by the heels 7a of the sub-needles 7 that are in the inactive position. The paths defined by the actuation cams 8 of the sub-needles 7 are shaped so as to force or allow the sub-needles 7, the heels 7a of which engage said paths, an upward or downward motion along the corresponding axial slot 3 of the needle cylinder 2 as a consequence of the rotation of the needle cylinder 2 about the axis 2a with respect to said cams 8.

The needle 4 also has, along its longitudinal extension, a heel 4a that lies radially with respect to the needle cylinder 2 and can engage paths defined by needle actuation cams, generally designated by the reference numeral 9 and rigidly coupled to the footing of the machine as regards rotary motion about the axis 2a. Said paths are shaped so as to force or allow the needles 4; the heels 4a of which engage said paths, an upward or downward motion along the corresponding axial slot 3 of the needle cylinder 2 as a consequence of the rotation of the needle cylinder 2 about the axis 2a with respect to the cams 9.

The means for actuating the needles 4 further comprise actuation means that act on command on the sub-needle 7 in order to produce its transition from the inactive position to the active position or vice versa.

Said means for actuating the sub-needle 7 comprise, for each sub-needle 7, a further actuation element 10, which is arranged in each one of the axial slots 3 below the sub-needle 7 and can move on command along the axial slot 3, i.e., parallel to the axis 2a of the needle cylinder 2, in order to interact with the lower end of the sub-needle 7 and produce its transition

or retention in the inactive position or in the active position.

The actuation element 10 comprises a selector 11, which is provided, along its longitudinal extension, with at least one heel 11a, 11b that is extended radially with respect to the needle cylinder 2. In the illustrated embodiment, the selector 11 is provided with two heels, respectively a lower heel 11a and an upper heel 11b, which are mutually spaced along the longitudinal extension of the selector 11.

The selector 11 can oscillate on a radial plane with respect to the needle cylinder 2 in order to pass from an active position, in which it protrudes radially with its lower heel 11a from the corresponding axial slot 3, to an inactive position, in which it is embedded with its lower heel 11a in the corresponding axial slot 3.

The upper heel 11b is constantly extracted from the corresponding axial slot 3.

Selector actuation cams, generally designated by the reference numeral 12, are arranged so as to face and lie around the outer lateral surface of needle cylinder 2 at a level that corresponds to the level of the selectors 11, and are rigidly coupled to the footing of the machine as regards rotary motion about the axis 2a. The selector actuation cams 12 define paths that can be engaged by the upper heel 11b and by the lower heel 11a when it is in the active position. These paths are shaped so as to force or allow the selectors 11, the heels 11a, 11b of which engage said paths, an upward or downward motion along the corresponding axial slot 3 of the needle cylinder 2 as a consequence of the rotation of the needle cylinder 2 about the axis 2a with respect to the cams 12.

The upper heel 11b, which is constantly extracted from the corresponding axial slot 3, is used mainly to actuate the lowering of the selector 11 by means of a part of the selector actuation cams 12.

The selectors 11 have, in a per se known manner, along their longitudinal extension, one or more selection tabs 11c, on which selection

devices 43a, 43b, 43c, 43d that face the outer lateral surface of the needle cylinder 2 act on command in order to produce the transition of the corresponding selector 11 from the active position to the inactive position. Transition of the selectors 11 from the inactive position to the active position can be achieved in a manner similar to what occurs for oscillating selectors in known types of machine, for example by virtue of extraction cams 13, which are arranged proximate to the lower end of the needle cylinder 2 and act on the lower end of the selectors 11. The selection devices, as well as the extraction cams 13, are arranged upstream of each drop 5 of the machine along the direction of rotation of the needle cylinder 2 about its own axis 2a with respect to the cam box.

The lower end of the sub-needle 7 is conveniently shaped complementarily with respect to the upper end of the actuation element 10, so that a movement of the actuation element 10 along the corresponding axial slot 3 of the needle cylinder 2 produces the transition of the sub-needle 7 from the inactive position to the active position or vice versa.

Conveniently, the lower end of the sub-needle 7 has a forked shape, in which a first prong 14a protrudes downward with respect to the second prong 14b.

Furthermore the first prong 14a is closer to the bottom, i.e., to the wall directed toward the axis 2a, of the corresponding axial slot 3, than the second prong 14b. The first prong 14a can be engaged by an upper portion of the actuation element 10 in order to move or stably retain the sub-needle 7 in its inactive position, while the second prong 14b can be engaged by the upper portion of the actuation element 10 in order to move or stably retain the sub-needle 7 in the active position.

Furthermore, the upper portion of the actuation element 10 can be inserted between the two prongs 14a, 14b of the lower end of the sub-needle for the very purpose of reinforcing the retention of the sub-needle 7 in the active position.

Conveniently, the actuation element 10 comprises, in addition to the selector 11, a pusher 15, which is accommodated so that it can slide within the corresponding axial slot 3 of the needle cylinder 2 between the selector 11 and the sub-needle 7.

In practice, the upper portion of the actuation element 10 that engages the lower end of the sub-needle 7 is constituted by the upper portion of the pusher 15.

The pusher 15 has, along its longitudinal extension, a heel 15a that protrudes from the corresponding axial slot 3 of the needle cylinder 2 and can engage paths formed by pusher actuation cams, generally designated by the reference numeral 16, which are rigidly coupled to the footing of the machine as regards rotation about the axis 2a. The paths defined by the actuation cams 16 of the pushers are shaped so as to force or allow the pushers 15, the heels 15a of which engage said paths, an upward or downward motion along the corresponding axial slot 3 of the needle cylinder 2 as a consequence of the rotation of the needle cylinder 2 about the axis 2a with respect to the cams 16.

The upper portion of each pusher 15 has, in a region that is spaced downward from the upper end of said pusher 15, a first region 17, which forms an inclined plane with respect to the longitudinal extension of the corresponding axial slot 3 and can engage a corresponding region 18 that forms an inclined plane and is provided at the lower end of the first prong 14a of the fork of the sub-needle 7, in order to achieve the transition of the sub-needle 7 from the active position to the inactive position as a consequence of the downward movement of the pusher 15 along the corresponding axial slot 3 of the needle cylinder 2.

The upper portion of each pusher 15 further has, at its upper end, a second region 19, which forms an inclined plane with respect to the longitudinal extension of the corresponding axial slot 3 and can engage a corresponding region 20, which forms an inclined plane and is provided at

the lower end of the second prong 14b of the fork of the sub-needle 7, in order to achieve the transition of the sub-needle 7 from the inactive position to the active position as a consequence of the upward movement of the pusher 15 along the corresponding axial slot 3 of the needle cylinder 2.

At the fork of the lower end of the sub-needles 7, the axial slots 3 have, on their bottom, a recessed region 25 for containing said fork and for allowing the oscillation of the sub-needle 7. Optionally, the upper part of said recessed region 25 may be shallower than the remaining part, so as to form a support for the forked region at least in the condition of maximum lifting of the sub-needle 7 that retains it stably in the active position.

The paths defined by the selector actuation cams 12 have, ahead of each drop 5 along the direction of rotation of the needle cylinder 2 about the axis 2a with respect to the cam box, a first rising portion 21 and a second rising portion 22, in which the peak is higher than the peak of the first rising portion 21 in order to produce lifting respectively up to a tuck-stitch lifting level and to a drop-stitch lifting level for the overlying needle 4. The rising portions 21 and 22 are meant to be engaged by the lower heel 11a of the selectors 11 in the active position.

Ahead of each drop or feed 5 of the machine along the direction of rotation of the needle cylinder 2 about its own axis 2a with respect to the cam box, there are four selection devices: two of said devices are located between the first rising portion 21 and the second rising portion 22.

Preferably, the knitting forming cams, also known as lowering cams, i.e., the cams that produce the descent of the needles after engaging the yarn at a drop, in the machine according to the invention, are part of the actuation cams 8 of the sub-needles 7. More particularly, at at least one drop and preferably at each drop there are two mutually opposite lowering cams 23 and 24 to produce the lowering of the needles after engaging the yarn at the drop being considered, to be used respectively in rotary motion in one direction of the needle cylinder 2 or in the opposite direction.

The lowering cams 23 and 24 can be movable on command, in a per se known manner, parallel to the axis 2a in order to vary the tightness of the knitting.

In practice, in the machine according to the invention there is preferably an arrangement and a configuration of the needle actuation cams 9, of the sub-needle actuation cams 8, of the pusher actuation cams 16 and of the selector actuation cams 12 that is symmetrical with respect to a radial plane of the needle cylinder that passes through a drop or feed. A similar symmetry also occurs in the arrangement of the selection devices 43a, 43b, 43c, 43d. This allows to actuate the needle cylinder 2 with a rotary motion about its own axis 2a equally in one direction or in the opposite direction.

The machine is completed with the elements that are usually present in circular knitting machines of this type, such as for example sinkers, fabric tensioning devices, various control systems, et cetera.

Optionally, the machine can be equipped with needles 4, sub-needles 7 and pushers 15 that have mutually different heel lengths.

Merely by way of example, Figures 1 to 4 illustrate four different operating conditions of a needle of the machine according to the invention. The direction of rotation of the needle cylinder 2 in the various figures is indicated by the arrow 30. The portions of the paths of the heels of the various elements in the active position have been shown by means of solid bars, while the portions of the paths of the heels of the various elements in the inactive position have been shown by means of broken lines. The needle 4, the sub-needle 7, the pusher 15 and the selector 11 have been shown, laterally with respect to the cam box portion, turned through 90° in a merely exemplifying position, since the position of these elements can vary according to the imparted actuation, as described below.

Figure 1 illustrates the condition in which the needle is excluded from knitting at a drop or feed 5 of the machine. To achieve this condition, the selector 11 of the needle 4 being considered is retained in the inactive

position by virtue of the selection devices. In this manner, the pusher 15, ahead of the drop being considered, is first lowered together with the sub-needle 7 and then returned to the lowermost position, causing the transition of the sub-needle 7 to the inactive position. In this manner, the corresponding needle 4 passes with its head below the lowering plane of the sinkers of the machine.

It should be noted that in this operating condition the heel 7a of the sub-needle 7 does not engage the lowering cams 23, 24, thus avoiding even small movements of the needle excluded from knitting, which occur in known types of machine and cause accidental breakage of the fabric when the needles that are excluded from knitting at the feed being considered carry knitting formed at other feeds of the machine.

Figure 2 illustrates the actuation of a needle 4 for forming a drop stitch.

In this case, the selector 11 of the needle 4 being considered is retained or moved into the active position by means of the selection devices so that its lower heel 11a engages both the rising portion 21 and the rising portion 22 of the path defined by the cams 12. In this manner, the pusher 15, after being lifted by the upward motion of the selector 11 engaged with the first rising portion 21 and assisted by a cam 31 of the actuation cams 16 of said pusher 15, is lowered by a cam 32 that again belongs to the cams 16 and causes the momentary transition of the sub-needle 7 into the inactive position in order to allow it to move beyond the lowering cam 23 without engaging it. The additional lifting produced by the engagement of the pusher 15 with the cam 33, which again belongs to the actuation cams 16 of the pusher 15, and of the selector with the rising portion 22, produces the lifting of the needle 4 up to the point where the previously formed loop of knitting is dropped onto the stem of the needle 4 before the needle 4 takes the yarn dispensed at the drop being considered and begins a new descent.

Figure 3 illustrates the actuation of a needle to form a tuck stitch.

In this case, the selector 11, by way of the selection devices, is engaged only with the rising portion 21. In this manner, the pusher 15 behaves as in Figure 2, except that at the drop 5 it does not receive the further upward motion that would be produced by the engagement of the selector 11 with the cam 22. For this reason, the needle 4 is raised to a lesser extent, and the loop of knitting is not dropped onto the stem of the needle 4 before taking a new yarn at the drop or feed being considered, but remains in the hook of the needle 4, which forms a new loop of knitting.

Figure 4 illustrates the actuation of a needle to form a floated stitch.

In this case, the actuation of the various elements is similar to the one described with reference to Figure 2, except that a movable cam 35 is inserted so as to act between the pusher actuation cams 16, causing a greater lifting of the needle 4 before it reaches the drop 5. Said greater lifting of the needle 4 has the effect of causing the transfer of the previously formed loop of knitting onto the stem of the needle 4 below the latch. In this condition, the needle 4 can then be actuated, by virtue of the selection device 43d, so as to reach a drop-stitch level, or can be retained at a tuck-stitch level. These two levels of lifting of the needle 4 can be used to make the needle engage different yarns dispensed at the drop 5, for example in order to make it engage two yarns when performing drop-stitch lifting and a single yarn when performing tuck-stitch lifting. Figure 4 illustrates the lifting of the needle 4 to the drop-stitch level.

It should be noted that in the machine according to the invention, the needle actuation means, constituted by the sub-needles, pushers and selectors, and the arrangement and distribution of the functions of the actuation cams of these elements allow to have as many as four selection points, two for each direction of rotation of the needle cylinder about its own axis, at each feed of the machine, with selection devices that can be arranged at the same vertical elevation.

Furthermore, the set of needle actuation means allows to contain

considerably the height of the needle cylinder and therefore to contain the inertia of the needle cylinder, allowing its actuation with an alternating rotary motion, even at relatively high speeds, about its own axis.

The possibility to rotationally actuate the needle cylinder in both directions of rotation and in particular the possibility to actuate the needle cylinder with an alternating rotary motion about its own axis allows to produce without problems three-dimensional shapes on the tubular articles that can produced with the machine, and to produce reinforced regions without varying the tightness of the knitting and without having to produce portions of courses of knitting to be trimmed.

In alternating motion, for producing contoured pouches, it is possible to perform knitting with progressive increases and decreases of the active needles simply by using the needle selection possibilities offered by the machine with adequate programming of the operation of the selection devices.

In addition to these possibilities, the machine according to the invention is capable of producing intarsia knitting, plated fabrics, Jacquard knitting on three technical tracks, striped fabrics, tuck-stitch knitting and floated-stitch knitting.

In practice it has been found that the machine according to the invention fully achieves the intended aim, since it is capable of producing articles with three-dimensional shapes without necessarily resorting to variations in the tightness of the knitting and without requiring the production of additional course portions with yarn trimming. The machine according to the invention also allows to perform intarsia knitting, i.e., knitting with colored designs without floated yarns on the reverse side.

The machine according to the invention is therefore capable of producing items of clothing of superior quality with respect to what can be achieved with circular knitting machines of a conventional type.

The machine thus conceived is susceptible of numerous modifications

and variations, all of which are within the scope of the appended claims; moreover, all the details may be replaced with other technically equivalent elements.

In practice, the materials used may be any according to requirements and to the state of the art.

The disclosures in Italian Patent Application No. MI2003A000900 from which this application claims priority are incorporated herein by reference.